Session No.15

Course Title: Breaking the Disaster Cycle: Future Directions in Natural Hazard Mitigation

Session Title: Measuring Hazard Mitigation Success: Issues in Measuring Mitigation Success

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Time: 150 minutes + 15 minute break

Objectives:

15.1 Understand the issues and background of attempts to measure the success of hazard mitigation, both before and after a disaster
15.2 Identify indicators of success
15.3 Describe quantitative measurement approaches, such as benefit cost analysis
15.4 Describe qualitative measurement approaches, such as case studies
15.5 Assess the political, social, and economic aspects of measuring mitigation success
15.6 Participate in a structured discussion about the credibility and validity of methods for measuring mitigation success

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Scope:

The first part of the session is a lecture on the issues and approaches to measuring success in hazard mitigation. The instructor discusses potential indicators of successful mitigation projects and processes, describes and critiques various quantitative and qualitative measurement techniques, and assesses the political, social, and economic aspects of successful mitigation.

The second part of the session is a structured discussion in the form of a debate on the pros and cons of alternative definitions and measures of mitigation success. Student teams make the case for and against benefit cost analysis and community studies, referring to evidence and positions in the literature to substantiate their arguments. They suggest practical techniques for measuring mitigation success at the national, state, and local levels.

Reading:

Instructor and student reading:

Association of State Flood Plain Managers. 2002. Arizona, pp. 3-7; Florida, pp. 17-18; Louisiana, pp. 27-34; Minnesota, pp. 43-46; Mississippi, pp. 49-50; South Carolina, pp. 77-84; Washington, pp. 89-90. *Mitigation Success Stories in the United States.* Edition 4. Madison, WI. (www.floods.org)

FEMA. 1997. *Report on Costs and Benefits of Natural Hazard Mitigation*, pp. 1-50. Washington, D.C.

FEMA. 1998. *Protecting Business Operations*: Second *Report on Costs and Benefits of Natural Hazard Mitigation*, pp. 1-41. Washington, D.C.

FEMA. Nd. Ch. 10, Benefit Cost Program: Print Out, Ch. 11, Glossary, pp. 105-119; Appendix 1, Economic Assumptions and Equations, pp. A1-12. *Benefit Cost Analysis of Hazard Mitigation Projects*. *Full-Data Flood BC Analysis Module*.

NC Emergency Management Division. nd. *Hazard Mitigation in North Carolina: Measuring Success*, pp. 1-84. Raleigh, NC: Department of Crime Control and Public Safety.

Additional instructor reading:

Handmer, John, and Paul Thompson. 1996. *Economic Assessment of Disaster Mitigation: A Summary Guide*. Canberra, Australia: Centre for Resources and Environmental Studies, Australian National University.

National Research Council. 1999. *The Impacts of Natural Disasters: A Framework for Loss Estimation*. Washington, D.C.: National Academy Press.

Burby, Raymond J. 2003. "Making Plans That Matter: Citizen Involvement and Government Action," *Journal of the American Planning Association* 69:1, 33-49.

Handouts:

Exercise Instructions

Overheads:

15.1 Measuring Success in Hazard Mitigation
15.2 Benefit Cost Analysis Terms
15.3 Critiques of Analytical Methods
15.4 Indicators of Success: A Sustainability Approach
15.5 Benefit Cost Analysis Methodology
15.6 Benefit Cost Example
15.7 Case Study Methodology

15.8 Case Study Example
15.9 Politics of Mitigation Analysis

General Requirements:
The instructor presents a lecture on issues and methods of measuring success in hazard mitigation the first part of the session. The second part of the session is an exercise in which teams of students debate the pros and cons of various techniques of measuring success in hazard mitigation.

Remarks:

During the previous class, students are formed into small teams and asked to prepare arguments for and against techniques of defining and measuring success in hazard mitigation. The discussion is carried out in the form of a structured debate.

15.1 Understand the issues and background of attempts to measure the success of hazard mitigation, both before and after a disaster

Defining and measuring "success" in hazard mitigation is a complex undertaking. Basically, there are two types of approaches, each with its own definition of success and its own analytical methods (*Figure 15.1 Measuring Success in Hazard Mitigation*):

- The *community impact analysis* approach relied on by planners and emergency managers, in which success is a function of the impact of mitigation projects and processes on community sustainability and on reduction in community vulnerability to natural hazards as measured through losses avoided as a result of mitigation
- The *benefit cost analysis* approach relied on by economists and public officials in which success is dependent upon ensuring that the benefits of mitigation (net change in direct and indirect future losses) exceed the costs of mitigation (expenditures on mitigation projects and processes).

Both methods can be applied before a disaster. When applied before a disaster, benefits must be inferred in terms of potential losses avoided by a probable future disaster. Community impact analysis also can be applied after a disaster, to measure benefits in terms of the losses actually avoided by pre-disaster mitigation activities, as well as potential losses that may be avoided from future disasters.

Examples of the community impact analysis approach are presented in the reports by the Association of State Flood Plain Managers (2002), FEMA (1997, 1998), and the North Carolina Emergency Management Division (n.d.). The general framework used in this approach is the "success story," in which a mitigation project and its costs are described and its impacts in reducing damage from an actual or potential hazard event are calculated. For example, the tax levy to fund the Flood Control District of Maricopa

County, Arizona, was used to fund projects on dam construction, channelization and bank erosion, which protected several billion dollars in property value in Phoenix, Glendale, Peoria and the State Capitol complex in a year 2000 storm for an investment of $23.2 million (in 1982 dollars) and protected some $15 million in property in North Wickenburg for an investment of $5 million (in 1996 dollars) (Association of State Flood Plain Managers 2002, p. 4).

Advocates of benefit cost analysis would reject the previous Arizona example as too imprecise in its specification of both benefits and costs. The benefit cost analysis approach is recommended by the U.S. Office of Management and Budget as the technique to use in a formal economic analysis of government projects and programs. (*Figure 15.2 Benefit Cost Analysis Terms*) Its output is described in terms of the ratio of the present value of costs to the present value of benefits. Use of this technique is justified on the grounds that it leads to better decisions in terms of providing the best return on investments of scarce resources, accountability to justify public decisions, and a consistent and rational comparison of available options and their consequences (Handmer and Thompson 1996, pp. 7-8). Benefits of mitigation are defined as losses avoided—both direct (such as building damage caused by physical impact of the hazard, such as flood water) and indirect (such as loss of production from an industry that is flooded). Future benefits and costs are reduced by application of the discount rate—the interest rate used in calculating the present value of expected future yearly benefits and costs. Discounting reflects the time value of money and the view that benefits and costs are worth more when they are experienced sooner. In the U.S., the Office of Management and Budget specifies the discount rate for analysis of federally funded projects, including Hazard Mitigation Grant Program (HMGP) projects.

Critics of the benefit cost approach allege that it is too narrow to capture the complete spectrum of mitigation benefits, many of which are intangible and thus difficult to measure. (*Figure 51.3 Critiques of Analytical Methods*) They also state that it is too mechanistic and formula driven, under-values future outcomes, and that the attempt to monetize benefits and costs causes it to make inappropriate assumption about the values of such things as human life and health, environmental quality, social community, and other non-economic values.

Critics of the community impact analysis approach allege that it is too broad and imprecise, and does not provide outputs that are comparable in terms of a single measure, such as dollars. Its success stories fail to provide consistent and convincing outcomes that are generalizable, but rather rely on a hand-picked set of cases chosen to support current financial assistance programs of FEMA and other federal agencies. This is sometimes labeled as “cherry picking,” on the grounds that the cases used are not representative of mitigation in general.

15.2 Identify indicators of success

Under the benefit cost approach, the main measure of hazard mitigation success is whether the long-term benefits exceed the long-term costs. When applied comprehensively, this approach will identify and measure both the direct and indirect losses attributable to hazards. However, the primary indicator of success is relatively narrow.

Under the community impact analysis approach, indicators of success are relatively broad. (*Figure 15.4 Indicators of Success: A SustainabilityApproach*) For example, the North Carolina Emergency Management Division (n.d., p. 6) defines success not only as effectiveness in reducing losses from natural disasters, but also as creating sustainable communities and building local hazard mitigation capacity.

Community sustainability is enhanced by

- siting buildings and infrastructure outside of hazard prone areas
- using design and construction techniques to strengthen buildings and infrastructure against hazard forces
- promoting businesses that can function following a disaster
- promoting agriculture that minimizes risk to natural hazards
- conserving natural resources, such as beaches, dunes, floodplains, and riparian areas, which act as buffers and ecosystem stabilizers.

Local hazard mitigation capacity is enhanced by the approach used in FEMA's Project Impact, whose focus is on sustaining mitigation efforts through the *institutionalization* of mitigation policies and programs. The typical elements include:

- Building community partnerships
- Identifying hazards and assessing risks
- Prioritizing and implementing hazard risk reduction actions
- Communicating successes.

To measure success, the North Carolina program addresses three issues:

1. How effective are the most used mitigation tools—acquisition and relocation of hazard prone properties and in-place elevations—in reducing losses?
2. How can communities utilize indicators to measure progress in reducing actual or potential disaster losses?
3. How can communities gauge their progress toward institutionalization of mitigation?

North Carolina defines long-term goals and performance indicators for sustainable housing, business, critical facilities and infrastructure, and the environment. The sustainable housing goal is to provide equal access to decent and affordable housing for the community citizens that meets their needs and is safe from the effects of natural and technological hazards. Indicators include:

- Number or percentage of households living in unsafe areas
- Number or percentage of households living in unsafe structures
- Number of repetitively damaged houses
- Percentage of households that carry flood insurance.

The sustainable business goal is to balance economic growth with strategies to reduce business vulnerability and minimize environmental damage. Indicators include:

- Number of businesses in unsafe areas
- Number of businesses in unsafe structures
- Number of businesses that have purchased adequate insurance to cover property casualty, fire, liability, loss of revenue, and flood damage
- Number of businesses that have conducted a business impact analysis, and have developed and implemented a business risk reduction plan.

The sustainable infrastructure and critical facilities goal is to be able to function effectively, particularly when the service supports life safety functions. Indicators include:

- Number and square footage of critical facilities (hospitals, emergency operations centers, police and fire stations, and schools) located in hazard-prone areas
- Number of repetitively damaged critical facilities
- Number of infrastructure elements (water supply, roads, bridges, sewerage, telecommunications, and port facilities) located in hazard-prone areas
- Number of repetitively damaged infrastructure elements
- Number of infrastructure elements that use design and construction techniques that strengthen individual components of the systems against hazard forces
- Increase or decrease in functionality of critical facilities and infrastructure systems following a major disaster.

The sustainable environment goal is use, conserve, protect and restore natural resources to ensure long-term social, economic, and environmental benefits and minimize man's impact on the natural environment. Indicators include:

- Number of unsafe land use activities in the 100-year floodplain or environmentally sensitive areas
- Number of commercial or industrial facilities in the 100-year floodplain or environmentally sensitive areas that have done structural or non-structural mitigation to reduce probability of release or spill of hazardous materials
- Number of activities that reduce flood water storage capacity, including stream channelization, wetland drainage and ditching, and filling of floodplains.

Obviously, measures of success will vary with the nature of the hazards faced. In terms of wildfire hazards, the measures might relate to zoning ordinances and building codes that dealt primarily with resisting or avoiding fire hazard areas. In term of tornado hazards, the measures might relate more to warning systems and safe room installations.

15.3 Describe quantitative measurement approaches, such as benefit cost analysis

Benefit cost analysis (BCA) is required of all FEMA-funded projects, in order to determine their eligibility for federal funding. The FEMA Hazard Mitigation Program website (http:www.fema.gov/hmgp) provides instructions and spreadsheets for calculating the benefit cost ratio (BCR) of various types of hazard mitigation projects, including floods, hurricanes, tornadoes, etc.

According to the manual for FEMA's *Full-Data Flood BC Analysis Module*, hazard mitigation projects are aimed at reducing or eliminating **future** damages through strengthening, elevating, relocating or otherwise improving buildings, infrastructure or other facilities to withstand damaging impacts. In some cases, hazard mitigation may also include training or public education programs if they can be demonstrated to reduce future damages.

Benefits are defined as avoided future damages and losses as a result of the mitigation project (the difference in expected future damages before and after mitigation). (*Figure 15.5 Benefit Cost Methodology*) Benefits must be estimated probabilistically because they depend on improved performance of the building or facility in future disasters, whose timing and severity must be estimated probabilistically. Benefits include: avoided damages to the building and contents, avoided displacement costs, avoided rental and business income losses, and avoided loss of public/nonprofit services. Costs are those necessary to implement the mitigation project.

Benefits are calculated over the useful lifetime of the mitigation project. To account for the time value of money, a net present value calculation must be performed. This calculation applies the discount rate (an interest rate that accounts for the time value of money, used to convert expected annual benefits over the project's lifetime to a net present value) specified by the Office of Management and Budget currently 7 percent) over the specified project useful lifetime.

The BCA analyst must provide the following information about the building or facility:

- building type
- building size
- replacement value
- contents value
- data about use and function
- hazard risk (probability of future events).

Geographic information systems are extremely useful in capturing, displaying, and analyzing these types of information.

An illustrative benefit cost analysis is provided in Chapter 10 of FEMA's *Full-Data Flood BC Analysis Module*. (*Figure 15.6 Benefit Cost Example*) In this example, a two story building is proposed to be elevated five feet to protect against future flooding. The project useful life is 30 years and the discount rate is 7 percent. Totaling the present value of expected building damages, contents damages, displacement costs, lost business income, lost rental income, and lost public services after mitigation yields project benefits of $30,999 versus project costs of $53,205. At a BCR of 0.58, the project does not meet the benefit cost standard, and could not be approved.

15.4 Describe qualitative measurement approaches, such as case studies

Case studies are useful in identifying benefits not normally covered under benefit cost studies. For example, the sustainable housing, business, environment, and infrastructure and facilities indicators proposed by the North Carolina Division of Emergency Management could be tabulated through data collection, interviews, and literature reviews. Such indicators offer a broader perspective on the long-term benefits of mitigation.

During a case study, the analyst compiles data on both mitigation projects (physical activities) and mitigation processes (institutional activities). Typically, the case study follows a systematic methodology such as one recommended in the social science literature. (*Figure 15.7 Case Study Methodology*) The analyst prepares a set of research questions and then collects information from a variety of community sources. In *Case Study Research: Design and Methods* (Sage Publications,1994), Yin notes that case studies are the preferred research strategy when "how' or "why" questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real life context.. He defines a case study as an empirical inquiry that investigates a contemporary phenomenon within its real life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

An illustrative community impact analysis case study might have the following research design (*Figure 15.8 Case Study Example*):

- Question: what is the impact of the mitigation program on sustainable housing?
- Proposition: mitigation strategies based on relocation must identify safe and feasible locations for relocates within the community in order to foster sustainability.
- Unit of analysis: relocation program.
- Criteria:
  Primary program benefits: number of housing units related in safe and feasible locations within the community, as compared with number of units dispersed to other locations
  Primary program costs: governmental expenditures on acquisition of units, moving costs, staff costs.
  Secondary program benefits: restoration of the original ecosystem in the cleared area, such as a wetland or stream buffer
  Secondary program costs: un-reimbursed moving expenses incurred by relocatees, social disruptions faced by relocatees in new neighborhoods

The analyst would collect data on the number of housing units relocated and where they were relocated, would interview project staff, review project documents, and interview relocated residents. He/she would seek information on the social and environmental impacts of the relocation program, as well as its physical and economic aspects. Thus, the community case study might discover a number of benefits and costs not tabulated under the benefit cost approach.

15.5 Assess the political, social, and economic aspects of measuring mitigation success

Measuring mitigation success is not a value neutral activity. (*Figure 15.9 Politics of Mitigation Analysis*) Governmental decision makers (federal, state, and local) prefer to receive a favorable report on the success of their mitigation programs and policies. Relocated households, including both homeowners and renters, want their experiences, pro and con, to be recognized by the community. Taxpayer groups desire favorable measurements of the efficiency of the programs in spending public funds. Public safety providers look to the analysis to find how it will affect their future disaster response activities.

Mitigation success often is influenced by the willingness of community leaders and elected officials to give priority to mitigation as an important public policy. Research on sixty local governments in Florida and Washington State found that involving stakeholders in the planning process tended to increase the implementation of planning proposals for actions to reduce potential losses from natural hazards. As Burby (2003, p. 44) states: "By involving stakeholders, planners can increase public understanding of these issues and persuade potential constituency groups of the need for action. With broader participation in plan making, planners develop stronger plans, reduce the potential for latent groups who oppose proposed policies to unexpectedly emerge at the last moment, and increase the potential for achieving some degree of consensus among affected interests."

The analyst attempting to measure mitigation success must walk a fine line between satisfying various stakeholder groups and providing an accurate and useful analysis of the relative success of the mitigation effort. In the long run, it is more valuable to have an honest and objective analysis that assists the community in learning how to employ mitigation as part of an overall sustainable development strategy than in producing a weak or slanted analysis to satisfy certain groups. If that involves reporting that some aspects of mitigation have not produced the expected or desired results, then the analyst should not shirk this responsibility.

15.6 Participate in a structured discussion about the credibility and validity of methods for measuring mitigation success

Students are assigned to two debate teams, one favoring benefit cost analysis and one favoring community impact analysis. Each team has twenty minutes to present its argument and ten minutes to rebut the other team's argument. Each presentation should include the advantages of its approach, a critique of the other approach, and examples from applications in disaster settings.

Figure 15.1 Measuring Success in Hazard Mitigation

Two main types of analytical methods:

1) *community impact analysis* ("success stories")

- **success = impact of mitigation on community sustainability & reduction in vulnerability to natural hazards as measured through losses avoided as a result of mitigation**

2) *benefit cost analysis* (economic analyses)

- **success = benefits of mitigation (net change in direct and indirect future losses) exceed costs (expenditures on mitigation projects & processes)**

Figure 15.2 Benefit Cost Analysis Terms

Benefits = ***losses avoided*** **through mitigation of:**

- ***direct losses*****: e.g., building damage caused by physical impact of hazard, such as flood water**

- ***indirect losses*****: e.g., loss of production from an industry that is flooded**

Discount rate **= interest rate used to calculate present value of expected future yearly benefits and costs**

Figure 15.3 Critiques of Analytical Methods

Critiques of benefit cost analysis

- **Narrow (fails to capture all benefits)**
- **Mechanistic (reduces all values to dollars)**
- **Formula driven (analysis only seeks ratio of 1+ & overvalues present vs future)**
- **Monetizing inappropriate for many non-economic values (life, health, environmental quality, social community, etc.)**

Critiques of community impact analysis

- **Too broad**
- **Imprecise**
- **Outputs not comparable**
- **Results not generalizable**
- **Success stories ignore failures**

Figure 15.4 Indicators of Success: A Sustainability Approach
(Source: *Hazard Mitigation in North Carolina*)

Goals:

- **Reducing losses from disasters**
- **Creating sustainable communities**
- **Building mitigation capacity**

Analysis questions:

How effective are mitigation tools—acquisition and relocation of hazard prone properties and in-place elevations—in reducing losses?

How can communities utilize indicators to measure progress in reducing actual or potential disaster losses?

How can communities gauge their progress toward institutionalization of mitigation?

Figure 15.4 Indicators of Success: A Sustainability Approach-2

(Source: *Hazard Mitigation in North Carolina*)

Sustainable *housing* indicators:

- **households living in unsafe areas**
- **households living in unsafe structures**
- **repetitively damaged houses**
- **households that carry flood insurance.**

Sustainable *business* indicators

- **businesses in unsafe areas**
- **businesses in unsafe structures**
- **businesses with adequate hazard insurance**
- **businesses with business impact analysis & business risk reduction plan**

Figure 15.4 Indicators of Success: A Sustainability Approach-3

(Source: *Hazard Mitigation in North Carolina*)

Sustainable *infrastructure &critical facilities* indicators

- **critical facilities (hospitals, emergency operations centers, police and fire stations, schools) in hazard-prone areas**
- **repetitively damaged critical facilities**
- **infrastructure elements (water supply, roads, bridges, sewerage, telecommunications, port facilities) in hazard-prone areas**
- **repetitively damaged infrastructure elements**
- **infrastructure elements with design & construction techniques that strengthen individual components against hazard forces**
- **increase or decrease in functionality of critical facilities &infrastructure systems following major disaster.**

Sustainable *environment* indicators

- **unsafe land uses in 100-year floodplain or environmentally sensitive areas**
- **commercial or industrial facilities in 100-year floodplain or environmentally sensitive areas mitigating against release or spill of hazardous materials**
- **activities to reduce flood water storage capacity, including stream channelization, wetland drainage & ditching, filling of floodplains**

Figure 15.5 Benefit Cost Analysis Methodology
Source: FEMA Full-Data Flood BC Analysis Module

The expected net present value, NPV, is defined as:

$$NPV = \frac{B_1}{1+i} + \frac{B_2}{(1+i)^2} + \ldots + \frac{B_t}{(1+i)^t} + \ldots + \frac{B_T}{(1+i)^T} - INV$$

where:

NPV is the expected Net Present Value of the hazard mitigation project;

B is the expected annual net Benefit of the hazard mitigation project for year t;

i is the annual discount rate;

T is the length of the planning horizon (useful life or Time of the hazard mitigation project); and

INV is the initial investment (the cost of the project).

Figure 15.6 Benefit Cost Example
Source: FEMA Full-Data Flood BC Analysis Module

Building type: **2 story**
Project useful life: **30 years**

Expected damages and benefits

	Expected annual damages before mitigation	Expected annual damages after mitigation	Expected annual benefits	Present value of annual benefits
Building damages	$1,052	$9	$1,042	$12,935
Contents damages	525	5	521	8,468
Displacement costs	142	1	140	1,741
Business income lost	35	0	35	431
Rental income lost	21	0	21	255
Public services lost	745	7	730	9,165
Total losses & benefits	$2,521	$23	$2,496	$30,999

Project benefits **$30,999**
Project costs **$53,205**
Benefits minus costs **($22,205)**
Benefit cost ratio **0.58**

Figure 15.7 Case Study Methodology

Case study:

- **empirical inquiry that investigates a contemporary phenomenon (e.g., hazard mitigation) within its real life context (e.g., a community)**
- **when boundaries between phenomenon and context are not clearly evident (e.g., how does the community itself affect & influence mitigation)**
- **in which multiple sources of evidence are used (e.g., records, data bases, interviews, documents)**

Figure 15.8 Case Study Example

- ***Question*: impact of mitigation program on sustainable housing?**
- ***Proposition:* relocation strategies must identify safe and feasible locations for relocatees within the community in order to foster sustainability**
- ***Unit of analysis*: relocation program**
- ***Criteria*:**

***Primary program benefits*: number of housing units related in safe & feasible locations within the community, as compared with number of units dispersed to other locations**

***Primary program costs*: governmental expenditures on acquisition of units, moving costs, staff costs**

***Secondary program benefits*: restoration of original ecosystem in cleared area, such as a wetland or stream buffer**

***Secondary program costs*: un-reimbursed moving expenses incurred by relocatees, social disruptions faced by relocatees in new neighborhoods**

Figure 15.9 Politics of Mitigation Analysis

Stakeholders

- **Government decision makers**
- **Relocate households**
- **Taxpayer groups**
- **Public safety providers**

Analyst

- **Be honest and objective**
- **Provide community learning**